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On the Life History of *Teinopalpus imperialis* HOPE in Northern India and its Phylogenetic Position in the Papilionidae

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Preface

Since Hope described *Teinopalpus imperialis* as a new species in 1843, many an entomologist has apparently made efforts to bring its early stages to light. F. M. BAILEY (1940) cites ELWES's report (1888) about KNYVETT's discovery of wild pupae on leaves of *Daphne nepalensis*, and Oscar LINDGREN's account on a mature larva he picked up on a path in September, 1918, which subsequently pupated and produced an imago. Both records lack exact localities but they are thought to be in the neighbourhood of Darjeeling.

Unfortunately, these two witnesses failed to leave any likeness of the larva or pupa they found, and the lack of concrete information as to their morphology has been largely responsible for a long stalemate in the study of this butterfly, particularly regarding its relation to other papilionid species.

The present author realized the significance of the early stages of *T. imperialis* in the classification of the family Papilionidae, and resolved in 1962 to visit some of its known haunts for field survey. In the following year, the Lepidopterological Society of Japan sent an expedition to Nepal Himalaya, in which he took part. Until 1986 when its life history was finally elucidated, he and/or his colleagues made a total of fourteen visits to Nepal and Northern India in search of the livestock of this species.

Nearly twenty-four years had elapsed without conclusive results due to various unfavourable conditions ; *T. imperialis* is by no means a common insect ; its real host plant or plants were unknown and, bad weather prevails in its haunts when it is on the wing.

The author spent a total of five months in Northern India between 1985 and 1986, and was fortunate enough to observe and put on record a vital part of its life history, the details of which is published herewith, accompanied by colour illustrations.

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Life History

1. Habits

Imagines: Males are active on fine days between 7: 30 a.m. and noon. They like to alight on tree tops or boulders on summits or ridges, forming territories. The approach of another male results in vigorous chases by the occupant males.

Their flight is very fast and flitting, not unlike that of a *Graphium* species. When at rest, they keep their wings open or half open. Once they have settled down on their perches, they may stay motionless for a long time; occasionally they do not even respond to a touch by a human hand.

When the sun is clouded, the males immediately stop flying and plummet to sit on nearby tree tops or even on the ground. On dull days sporadic flights, perhaps incited by some stimulus, can be seen but such tend to come to a halt very soon.

According to the author's observations, feeding appeared to be limited to moisture on leaves or on the ground. However, Mr. Shinsuke TAKIZAWA twice spotted on Tiger Hill a male visiting white flowers of a low plant, when it sat with the wings open and fed on the nectar.

Females, like males, are most often seen flying to the summit. They also prefer sunny spells but hardly fly on cloudless, calm fine days. They appear to like breezy, foggy days with intermittent sunshine best of all. Unlike males, females fly on cloudy days or even in showers.

Females are usually on the wing from 8: 30 a.m. to 0: 30 p.m., and most of the captures took place around 11 a.m.

A total of 14 females have been taken by the author and his collaborators so far on the top of Tiger Hill. They were all fresh and proved to be virgin females. Not a single battered specimen was included. This fact strongly suggests that those

females flew up to the summit in search of males, rather than were blown up by the wind. In this connection, it is worthly of note that females of two other papilionids, *Achillides krishna* and *A. arcturus*, collected in the same place are often fresh and mostly virgins.

The flight of the female is less powerful than that of the male. It flies more or less directly towards the summit, where it turns once or twice and then flies away down the hill. On two occasions females were nearly caught and the net bag grazed them. Then, as if feeling dizzy from a whirlwind, they flew down to cling to an object nearby, and remained still for a while.

No females were seen feeding in the wild, either from flowers, wounded trees or moisture. The author saw one drinking dewdrops that had condensed inside a polyethylene bag. If forced, the female readily feeds on thin solution of honey or even of whisky. But these seem to do the butterfly more harm than good, often resulting in a premature death.

In captivity, only water will suffice for the maintenance of the butterfly's vitality. It is remarkable that the butterfly does not tolerate excessively moist condition in confinement, despite its adaptation to the humid, misty mountainous terrain. It dies in a few days if it is continuously kept under 100% humidity, for instance in an airtight bag.

2. Number of broods

On Tiger Hill (altitude : 2,585 m), the butterfly starts emerging in late April, and becomes most abundant in the latter half of May. Many still occur in June, but the number of butterflies quickly dwindles in July and very few indeed are seen in August. Yet the fact remains that many of the specimens collected in July and August are quite fresh. The author believes that the butterfly is univoltine, the emergence taking place over a very protracted period of nearly five months. In view of the fact that at least two full months were necessary for the development of a freshly laid egg to the pupal stage, the Tiger Hill population of this butterfly is considered to be univoltine. It should be added, however, that about half of the pupae that the author reared indoors hatched between August and September.

Eleven pupae brought to Japan were contained in a cloth bag and kept outdoors, as they were considered to be in diapause. In early December, 1986, however, four of them showed signs of forming up. These were then taken indoors but not forced. The emergence of three males and a female ensued in late December in an unheated room where the maximum temperature was 10° to 13℃. It is interesting to note that all of these pupae initially looked exactly the same in colouring as the others (see Morphology of pupa), and that the resulting butterflies were typical spring specimens, unlike the summer form characterized by long-extended forewing apices. It is said that the winter at the summit of Tiger Hill can be quite cold, the mercury falling down even to minus 21℃. The maximum temperature from late autumn to early winter in the Tokyo-Yokohama area ranges between 7 and 13℃, which corresponds to the spring on Tiger Hill. This can be one reason for the untimely hatching of the four pupae.

Possibly lighting at night accounts for this. Mr. D. M. WANKHAR tells me that, on the Khasi Hills (altitude : ca. 1,500 m) many butterflies emerge also in September and that they are most probably double-brooded. If that is the case, the lower altitude of the Khasi Hills, hence a warmer climate, is responsible.

3. Courtship behaviour

During July and August, 1985, the author always recognized a male butterfly perched on the top of an approximately 15 metre-high tree standing at some 30 metres north of the summit of Tiger Hill. It apparently commanded a territory. At 10 : 05 a.m., August 25th, a female approached the summit from the northwest, made a round turn above the summit and was about to fly away northwards, passing by the tree top at a distance of about 5 metres. Immediately the male took to the wing and chased the female. The female appeared to fly faster to flee, but the male also accelerated and nearly collided with the female. Thereupon the two butterflies plummeted on to the densely wooded steep slope and hid from view. Neither reappeared and the author concluded that the courtship was successful.

4. Mating

Neither the author nor his cooperators saw even one pair of butterflies in copula in the wild.

On May 25th, 1986, the author put into a mating cage of cloth a freshly caught pair of butterflies in expectation of a spontaneous mating. Even though they were quite active in the cage and came into contact with each other on more than one occasion, no advance was made by the male and they failed to pair. They were left in the cage from 9 to 10 a.m. The weather was fine and the temperature 18℃.

The author then hand-paired the same butterflies. Copulation lasted for 2 hours 16 minutes from 10 : 19 a.m. to 0 : 35 p.m. The mean temperature during this period was 20℃.

Then, on May 29th, a hand-pairing between different individuals was successfully obtained. They were in copula for one hour 7 minutes from 8 : 41 to 9 : 48 a.m. The weather was fine, and the temperature averaged 18℃. That is to say, the mating was completed in less than half the duration of the first case depite the lower temperature. On June 6th, a third female was netted and hand-paired the same day. The butterflies were in union for 3 hours 40 minutes, from 2 : 05 to 5 : 45 p.m. The weather was rainy and the temperature 18℃.

It is interesting to note that, under more or less the same temperature, the durations of the three pairings differed so much. Incidentally, a hand-pairing of *Achillides krishna* in the evening resulted in a very long mating.

Their subsequent oviposition did not appear to be affected by the difference in the duration of pairing.

As far as the hand-paired individuals are concerned, this butterfly behaved similarly to common papilionids during copulation.

5. Oviposition in capitivity

The author tried to induce a female, taken on August 18th, 1985, to lay on various plants in captivity at 2 p.m. on August 23rd. With no idea about the larval food plants of this butterfly, leaves of the following plants were used on a trial basis:

Litsea kingii (Lauraceae)
Neolitsea zeylanica (Lauraceae)
Xanthoxylum alatum (Rutaceae)
Xanthoxylum acanthopodium (Rutaceae)
Evodia flaxynifolia (Rutaceae)
Daphne nepalensis (Thymelaeaceae)

The last mentioned has been reported as a food plant. However, the butterfly did not show any interest either in this or any of the others.

Then between 8: 30 and 9: 45 a.m. on August 27th, he offered the female the infusion paper of the following two plants.

Lindera umbellata (Lauraceae) ....no response
Liriodendron tulipifera (Magnoliaceae) ....11 eggs laid

The result made him almost confident that its natural food plants would include magnoliaceous species. On the following day he picked some leaves of *Magnolia campbellii* growing on Tiger Hill, and brought the female in contact with them. It subsequently laid eggs on them.

Then on June 5th, 1986, he successfully induced a female to lay 12 eggs on the same plant. As a result, it was considered certain that *M.campbellii* is a larval food plant, at least on Tiger Hill. In fact, it is the only magnoliaceaeous plant growing between the top of Tiger Hill and 300 metres below.

Also in 1986, infusion papers of the following three plants prepared in Japan were used.

Illicium religiosum (Magnoliaceae) ....no response
Kadsura japonica (Magnoliaceae) ....no response
Magnolia obovata (Magnoliaceae) ....many eggs laid

Incidentally, Mr. D. M. WANKHAR has told the author that he once had a female lay a little more than a dozen eggs on a polyethylene bag into which it was confined without any plant whatsoever, but that none of them had hatched.

In the 1985 trials, the females laid eggs in capitivity only in the morning, the exception being one egg laid in the afternoon. However, in 1986, it was found that eggs could also be laid in the afternoon. All females kept in captivity reacted against direct sunshine, wildly fluttering and refusing to lay. They seemed to like weak or dappled sunshine. In one case a female laid eggs in twilight, under three candle lights indoors.

When intent on laying, the female holds the filter paper or a leaf with its legs, moderately fluttering its wings. After laying one egg, it flies about and, fluttering about in the bag for a few minutes, deposits another egg at a distant piece of paper or leaf. It never laid on the underside of the paper. This suggested that the butterfly would lay its eggs singly on the upperside of leaves, not in batches or on the underside. This was exactly the case in the wild, as it turned out later on. In the 1985 trials, the

female laid only about 10 eggs a day, despite attempts to make it lay more. In 1986, however, a female laid no less than 53 in a single day. This may be due to an individual difference, probably influenced by her age or condition until the day before.

6. Oviposition

Even though a local food plant was discovered, hardly any wild females could be seen in the act of laying eggs. The rare observation was made by Mr. Hirotaka MATSUKA at 2 : 55 p.m. on July 2nd, 1986. According to his account, a female came flying from the north and flew around four trees of *Magnolia campbellii* growing on mid-slope of Tiger Hill (altitude : ca. 2,535 m). It alighted on a leaf of a twig extending to the west and stayed there for about a second and then flew away.

The tree was some eight metres tall and the twig in question was near its top. His inspection by binoculars was inconclusive. The following day, he cut off the twig and examined its leaves. As expected, an egg was found laid on the midrib of a mature leaf. The leaf measured 23 cm long and the egg had been laid at about 9 cm from the base of the leaf. The weather on July 2nd was cloudy with intermittent sun, and the temperature was 20℃, which was fairly high.

7. Food plants

The known larval food plant in the butterfly's habitat on Tiger Hill is *Magnolia campbellii*. This magnificent deciduous tree is confined in North India to altitudes above 2,200 metres. In July, 1986, the author gave the larvae in capitivity leaves of *Liriodendron tulipifera* (Magnoliaceae), *Magnolia liliflora* (Magnoliaceae), *Magnolia* obovata (Magnoliaceae) brought from Japan, all of which were readily accepted.

Also, the larvae fed without hesitation on leaves of an evergreen *Magnolia* sp. growing below 2,200 metres in the Darjeeling district.

This fact appears to indicate that the butterfly population in areas below Tiger Hill where *Magnolia campbellii* is absent probably depends on other magnoliaceous plants.

8. Notes on early stages

Egg : On average, the egg stage lasts for 15 days. It varies slightly with the individual egg, so that eggs laid earlier on a day do not necessarily hatch ahead of those laid on the same day. There was no difference in the length of the egg stage between the eggs laid in May and those in July. Fifteen days is quite long for the egg stage of a papilionid, apart from *Parnassius*, whose eggs hibernate.

The pale purple red egg does not change colour until the 12th day when, suddenly, the black larval head becomes visible. Subsequently, the moving larval body is seen through the egg-shell, but it is not until two days later that the larva hatches.

First-instar larva : On extricating itself from the eggshell, the larva consumes most of it, leaving a disc on the leaf. Even though the egg laid in the wild was on a hard leaf, the newly-hatched larva moves to fresh leaves which are purplish, or quite young leaves. Unless it is feeding, It rests on a silk pad spun on the leaf.

Fig. 1. Leaf of *Magnolia campbellii* HOOK. f. & THOMS.

Second-instar larva : It keeps to the upper side of the leaf. When at rest, it keeps its fore half bent about 45° to the right, rarely to the left. The second instar lasts for about six days.

Third-instar larva : It no longer bends the body at rest. It usually sits with the thorax dilated, with the result that the abdominal segments are contracted. The third instar lasts for about seven days.

Fourth-instar larva : It sits on the upperside of the leaf, with the head turned towards the leafstalk. It avoids exposure to direct sunshine. When irritated, it protrudes its osmeterium and swings the anterior part of the body right and left. The silk pad spun on its seat leaf is thick and firm, making it difficult to remove the sitting larva from its seat. It leaves the seat and feeds on other leaves, returning to the seat leaf after the meal. When at rest, it strongly swells its thorax and shrinks its abdomen. The duration of the fourth instar is rather varied, ranging from eight days to two weeks.

Fifth (last) -instar larva : Its habits are mostly the same as before. The seat leaf is profusely lined with silk. Unlike the mature larvae of *Achillides krishna* and *A. arcturus*, that of *T. imperialis* is hard to remove from its seat leaf. It is very voracious, consuming a leaf of ca. 25 cm in length in one day. The freshly-eaten edge of the leaf is moist with saliva for about 1 mm. Its faeces are compact and solid, and become very hard as they dry. One faecal pellet measures about 5.5 mm in diameter and about 6 mm long. It is twiçe as large in volume as that of *A. krishna.* The larva feeds more frequently towards 7 p.m., although it occasionally does so in the daytime. The fifth instar lasts rather long, ranging from 13 to 19 days. Thus, larvae from even the same clutch of eggs pupate over a protracted period of time.

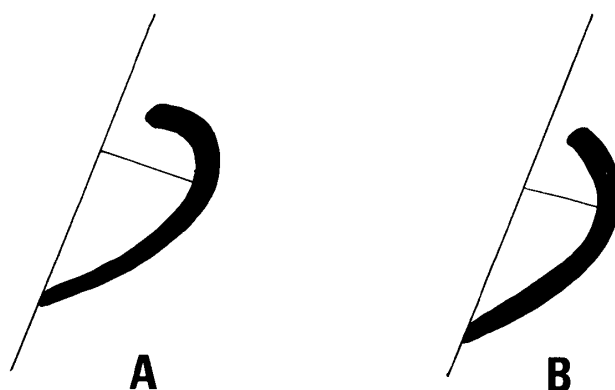



Fig. 2. Prepupal postures. A. *Teinopalpus imperialis* ; B. *Achilides krishna.*

The fully grown larva does not easily extrude its osmeterium even with a strong stimulus. Even if it does, it does not extrude the organ to its full length.

The silk girth spun at the time of pupation is comparatively long. The prepupa is more strongly hunchbacked than in other papilionids. The prepupal period is also long, lasting for four days.

All the 34 examples reared in cloth sleeves pupated on twigs. Not one chose the underside of a leaf, even though there were numerous leaves remaining in them.

Morphology

Egg : Nearly spherical with a shallowly concave bottom ; reddish purple in colour, with subdued gloss ; ca. 1.90 mm in diameter and ca. 1.52 mm in height.

First-instar larva : Similar in form to true *Papilios*, with a swollen thorax. Head, 1.07 mm in width, glossy dark brown with a slight yellowish tint. Hairs black, arranged in a most primitive manner as in Zerynthiini and Parnassiini, but a few more in number. The three setae a b c shown in Fig. 4 are charactristic of this species. Osmeterium yellowish orange. Prothoracic shield brown, provided with a wart-like growth on either extremity. It has with seven long hairs bending forward, which are brown in the middle and paler both at the tip and the base. Body dark brown, with a diagonal white band starting from the basal line on the 3rd abdominal segment, extending laterally on the 4th segment and both meeting at the posterior margin of the

same segment. The 5th abdominal segment white, sparsely spotted with dark brown. On the 6th abdominal segment the white area is much reduced, only present between the spiracular and based lines. Each segment from the mesothorax to the 9th abdominal segment carries a pair of long, dark brown dorsal setae ; a similar seta exists on the subdorsal line on each of these segments. Suranal plate brown, with 16 long, brown and white-tipped setae. Thoracic legs glossy dark brown, and prolegs white.

Second-instar larva : Similar to other larvae of the true *Papilio* group in respect of the swollen thorax ; latter half of the body remarkably elongated, which is a feature of this species. Head, ca. 1.69 mm wide, glossy and greenish brown in colour, with pale green patches on the vertex and both sides. Osmeterium yellowish orange. Colour of the body brownish green for the anterior half, gradually changing into brown in the posterior half and completely brown at the caudal end. Prothoracic shield also brownish green, with a hemispherical wart-like growth on either end. Round, light blue dorsal spots appear at this instar : one each on either side of the dorsal line and on the subdorsal line on the mesothorax and metathorax, and only on the subdorsal line on each of the 1st to 8th abdominal segments. White, reticular saddle mark on the lateral and dorsal parts of the 4th and 5th abdominal segments. A distinct white basal belt runs from the third to last abdominal segments. Suranal plate glossy brown, with short brown hair. Thoracic legs green, and prolegs yellowish grey.

Third-instar larva : Morphologically similar to the 2nd-instar larva except that the thorax is proportionately more flattened, and that the posterior half of the abdomen is not so slender as in the previous instar. Head, ca. 2.52 mm wide, glossy and pale green, with small yellow points widely scattered in the frontoclypeus and lateral areas which are separated in the middle by a zone devoid of yellow points. Osmeterium yellowish orange and not very long. Body slightly brownish green, dotted with small black points above the spiracular line on the thorax and the anterior half of the first abdominal segment. Similar points of a dark brown colour are scattered from the posterior half of the first abdominal segment onwards. Prothoracic shield green with irregularly distributed small black points, also terminating in hemispherical wart-like growths. The pale blue spots on the mesothorax and metathorax are still present, and the dorsal spots on the 1st to 3rd abdominal segments are also pale blue, but those on the 4th and 5th abdominal segments are white. A conspicuous white basal belt runs from the 1st abdominal segment to the caudal end. Suranal plate glossy green, and more elongated towards the head than in the previous instar. Thoracic legs pale green, with the claws slightly red-tinted. Prolegs yellowish green.

Fourth-instar larva : Body shape similar to that of the 3rd-instar larva ; thorax rather compressed, with a flat dorsum. Head, ca. 3.67 mm wide, glossy pale green, with yellow points widely scattered on the frontoclypeus and lateral areas, with a vertical zone devoid of yellow points in the centre. Osmeterium yellowish orange, strongly curved inwards when fully everted. Body dark green, scattered with very short broken black lines above the spiracular line on the thorax and the anterior half of the 1st abdominal segment ; elsewhere, from the posterior half of the 1st abdominal segment onwards, these are replaced by round indistinct dark brown dots of irregular distribu-

tion. Prothoracic shield dark green, dotted irregularly with large and small black points, ending in hemispherical wart-like growths. On the metathorax, a pair of subdorsal eyespots, pupilled with pale blue, replace the pale blue spots of the 3rd instar. The distribution and colouring of all other subdorsal and dorsal round spots are the same as in the previous instar. White saddle mark on the 4th and 5th abdominal segments broader and more pronounced than in the 3rd instar. A white basal belt is conspicuous from the 1st abdominal segment to the caudal end. Suranal plate glossy green, elongated and trapezoidal. Thoracic legs glossy pale green with red tips. Prolegs rich yellowish orange.

Fifth-instar larva: Generally similar to larvae of the true *Papilio* group in respect of the swollen thorax but much flatter, the relative dilation of the thorax becoming less conspicuous with aging. Head, ca. 5.59 mm wide, pale green with a slight orange hue which becomes stronger downwards, but no longer glossy; frontoclypeus similarly coloured but glossy. Osmeterium yellowish orange, curving inwards as in the 4th instar, and not very large for the larval size, emitting a similar but more pungent odour than those of common papilionids. Body dark green, becoming more yellowish downwards. Very short, broken black lines are also present above the spiracular line and much longer than in the previous instar.

These are also replaced by black points arranged irregularly from the posterior half of the 1st abdominal segment to the caudal end. Prothoracic shield dark green, irregularly dotted with large and small black points. Hemispherical growths of the shield very small and inconspicuous. Subdorsal oval eyespots on the metathorax bright reddish brown, white-pupilled and thinly defined with black. The two blue spots between the eyespots thickly margined with black; the corresponding spots on the 1st to 8th abdominal segements light blue and thinly demarcated with black. The white saddle mark on the 4th and 5th abdominal segments is conspicuous immediately after the 4th moult but gradually fades away as the larva grows, being eventually reduced to white lateral patches on each of these segments. The basal line from the 1st abdominal segment to the caudal end is broadly overlaid with bright yellow. Suranal plate glossy green, elongated and trapezoidal. Thoracic legs red but prolegs and anal prolegs bright yellow; the latter angular and extruding outwards from the caudal end. The body length of a fully grown larva at rest ca. 63 mm (cf. 48 mm in a comparable larva of *Achillides krishna*).

After spinning up for pupation the larva discolours drastically, with the head turning greyish brown and the body, rich yellow. A bright red dorsal patch appears on the thorax to the 1st abdominal segment and another from the 6th abdominal segment onwards. A green oval spot emerges on the dorsum of the mesothorax. A thick reddish brown belt runs over the subspiracular line from the thorax to the caudal end. The segments develop numerous regularly-distributed reddish purple dots, while the eyespots and subdorsal blue spots discolour and become quite inconspicuous.

Pupa: Bright green, translucent, flat and broad, almost rhombic in dorsal view. Head ptotruding, smooth but laterally ridged, not unlike a shark's snout in shape; entirely devoid of a pair of horns or projections which are so commonly found in the

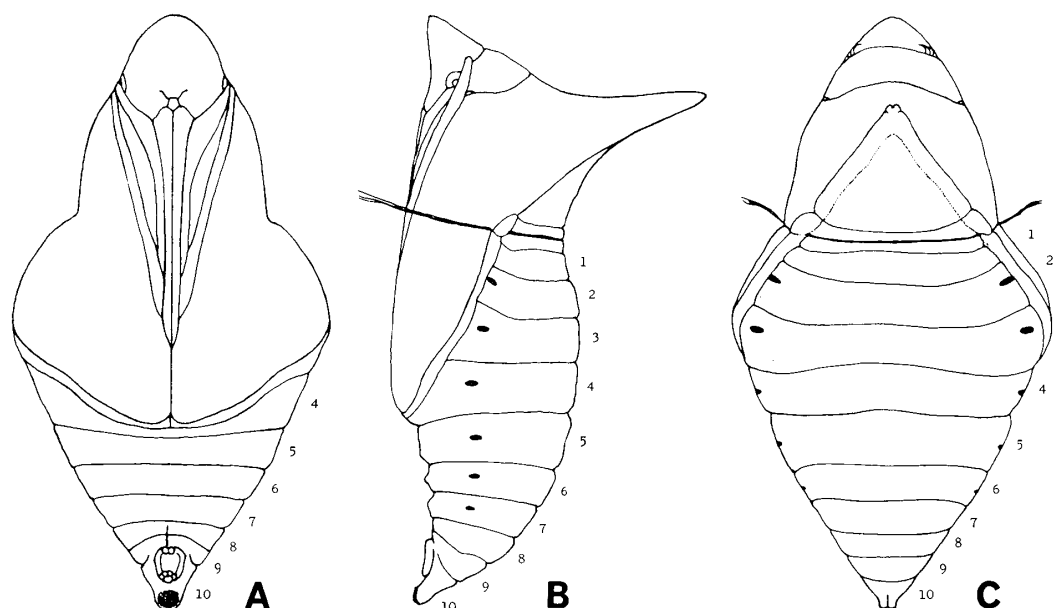



Fig. 3. Pupa of *Teinopalpus imperialis himalaicus*, female. A. Ventral aspect; B. Lateral aspect; C. Dorsal aspect.

pupae of most other papilionids. Not a single brown pupa was obtained, even though the larvae pupated on twigs under different circumstances.

The overwintering pupa tends to be more translucent, and dorsally more greenish, than the pupa that hatches without wintering; the latter is yellowish dorsally. Eyes small; proboscis much shorter than the wingcase; antennae slightly shorter than the proboscis. The extremities of the fore legs are hidden under the antennae, and those of the middle legs also similarly concealed but to a greater extent, so that the middle legs are less exposed than the fore legs. There is a prominent green horn on the dorsum of the mesothorax, with the caudal side grooved and bright green medially. Laterally viewed, the angle between the horn and the horizontal axis of the body is not constant, being almost 90° in the illustrated specimen. The 2nd to 5th abdominal segments strongly expanded laterally along the spiracular line. Vestiges of prolegs conspicuous on the 5th to 7th segments in the form of warts. A distinct dorsal line of a string pattern is recognizable from the tip of the mesothoracic horn to the caudal end, accentuated by a very broad yellow belt between the metathorax and the caudal end. This yellow dorsal belt is very bright immediately after pupation but becomes less distinct with the passage of time. Spiracular line from the 3rd abdominal segment onwards defined with a broad, dark green belt and a greyish white subspiracular belt. The bright reddish brown crochets are confined to the ventral side and invisible from the dorsal side, which is an exception among the papilionids. Silk girth very long, giving the pupa a greater angle against the twig to which it is attached than in other papilionids. Both girth and anal silk pad very dark brown in colour. Female pupae measured on average ca. 40.1 mm in length and ca. 20.2 mm in maximum width, and male pupae, ca. 39.7 mm and 19.2 mm, respectively. The average pupal weight is approximately 4.2 grams, or twice that of *Achillides krishna*.

Discussion

Opinions were divided in the past as to whether *Teinopalpus imperialis* belongs to the Papilionini or the Leptocircini. Here are the views of some authors:

FORD (1944) .... Papilionini
SHIRÔZU (1955) .... Papilionini
EHRLICH (1958) .... Leptocircini
MUNROE (1960) .... Leptocircini
IGARASHI (1984) .... Leptocircini

Now that the morphology of each early stage of this species has been clarified, it will be useful to review these opinions on its classification in the light of the new information.

1. Characteristics of the early stages

Egg: Its lateral view approximates *Papilio, Menelaides* and *Achillides*, being slightly flat. In contrast, eggs are almost spherical in *Graphium*.

First-instar larva: The chaetotaxy of the cranium is closer to the most primitive type with the least number of setae (*Luehdorfia, Parnalius, Hypermnestra, Archon, Meandrusa, Graphium* etc.) rather than to the hirsute type (*Papilio, Menelaides, Achillides* etc.). In fact, it only differs from the most primitive type by three additional setae.

In respect of the prothoracic shield, *T. imperialis* is considered to be primitive, approximating *Luehdorfia*. In *Papilio, Menelaides* and *Achillides*, the plate has a well-developed projection on either side which is provided with normal setae. In *Graphium*, too, the projections are similarly prominent but their setae are bifid. The shield of *T. imperialis* only has wart-like growths rather than projections, and there are merely seven long normal setae on either wart.

On the subdorsal line, there are single long normal setae, whereas cactiform projections exist in *Papilio, Menelaides* and *Achillides,* and in *Graphium*, there are warts each with several bifid setae. This feature again is a characteristic similar to those of *Luehdorfia* and *Parnalius*. Below the spiracular line, however, each segment has more setae, as in *Chilasa* and *Papilio*.

The suranal plate simulates those of *Luehdorfia, Parnalius, Menelaides, Papilio* and *Achillides*, differing entirely from that of *Graphium* which in provided with a pair of long projections.

The body, with its swollen thorax and white saddle mark on the abdomen, approximates those of *Papilio, Menelaides* and *Achillides,* and differs either from *Luehdorfia* and *Parnalius* or even from *Graphium*. It must be emphasized, however, that the white saddle mark straddles the 4th and 5th abdominal segments in *T. imperialis*, as against the 3rd and 4th abdominal segments in *Papilio, Menelaides* and *Achillides.*

Second to fifth instar larvae: Though different in minor respects, *T. imperialis* is generally similar to *Papilio, Menelaides* and *Achillides* rather than to *Graphium.*

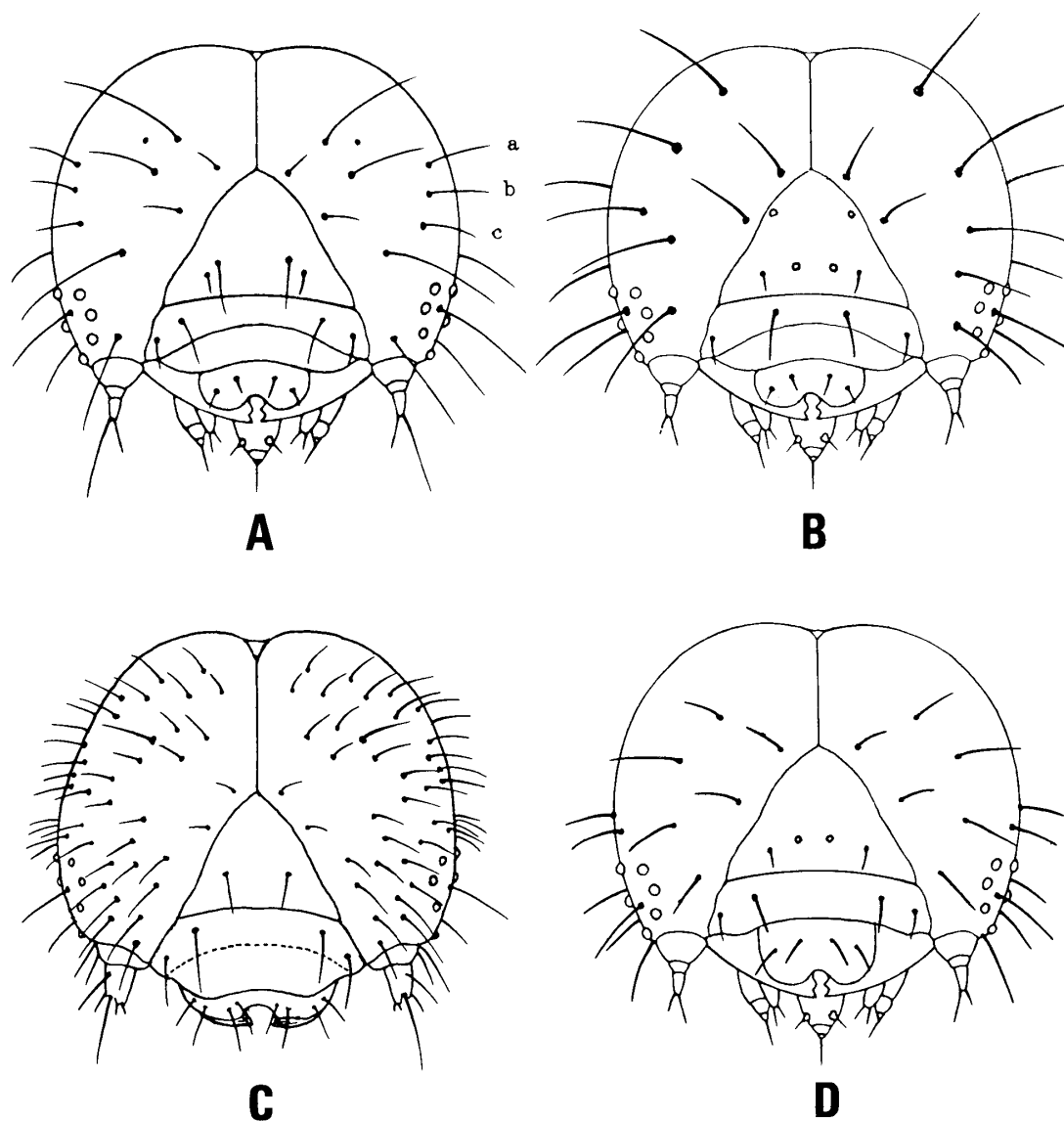



Fig. 4. Head chaetotaxies in first-instar papilionid larvae. A. *Teinopalpus imperialis* ; B. *Parnalius cerisy* ; C. *Menelaides protenor* ; C. *Graphium sarpedon*.

While subdorsal projections (or points later) on the thorax and well-developed projections on the anal plate are characteristic of *Graphium*, no trace of these is found in this species. In contrast, the metathoracic subdorsal eyespots, round blue or white spots and the white saddle mark suggest some similarity to *Achillides*. The suranal plate elongated in these instars into a trapezoidal from is unique to this species. Fine, fairly long normal setae are sparsely distributed on the surface of the body.

Pupa : In appearance it closely resembles *Graphium* spp. in having a smooth head as well as a prominent dorsal horn on the mesothorax. In *Graphium*, however, this horn is folded backwards (i.e. towards the tail) in the prepupa, whereas it is otherwise folded in *T. imperialis*. In the *Papilio* group the mesothoracic projection is folded forwards (i.e. towards the head) in the prepupa. In this respect *T. imperialis* is considered closer evolutionally to *Papilio* than *Graphium*.

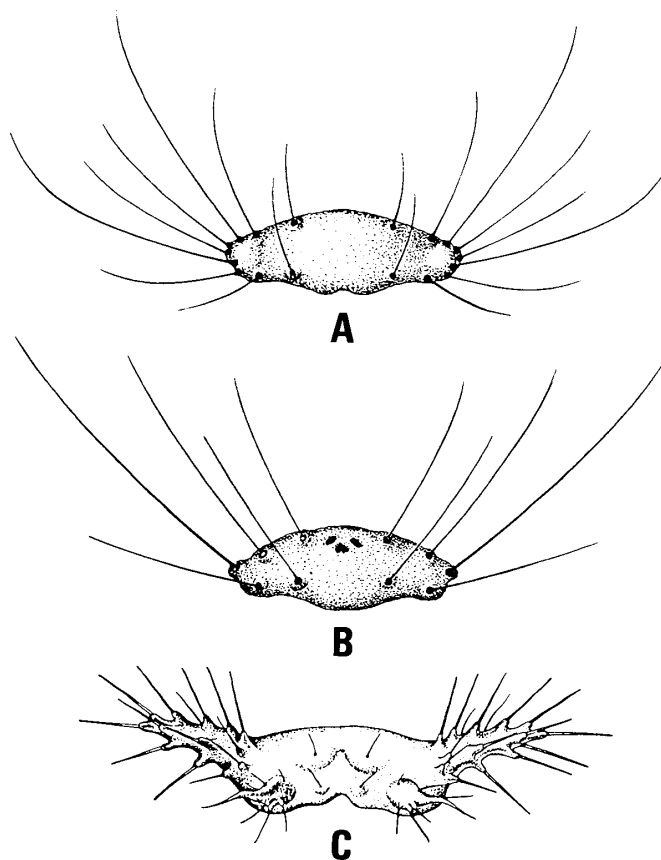



Fig. 5. Prothoracic shields in the first-instar larvae. A. *Teinopalpus imperialis*; B. *Luehdorfia japonica*; C. *Menelaides protener*.

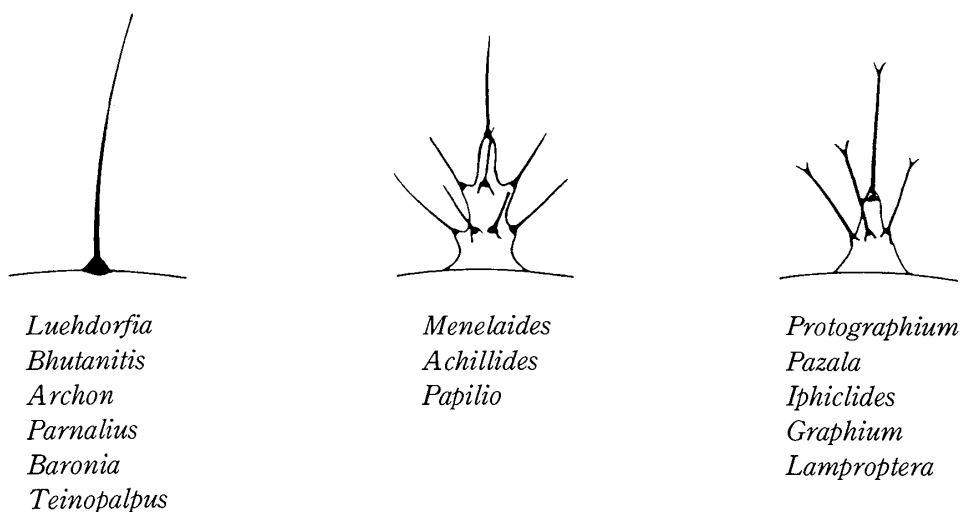



Fig. 6. Projections and setae in the first-instar papilionid larvae.

In *Achillides* there is a distinct dorsal line, or a moderate ridge, on the abdominal segments, while in *Graphium* such is absent and two subdorsal lines or low ridges run along the abdomen. In *T. imperialis* there is a dorsal line like that of *Achillides*.

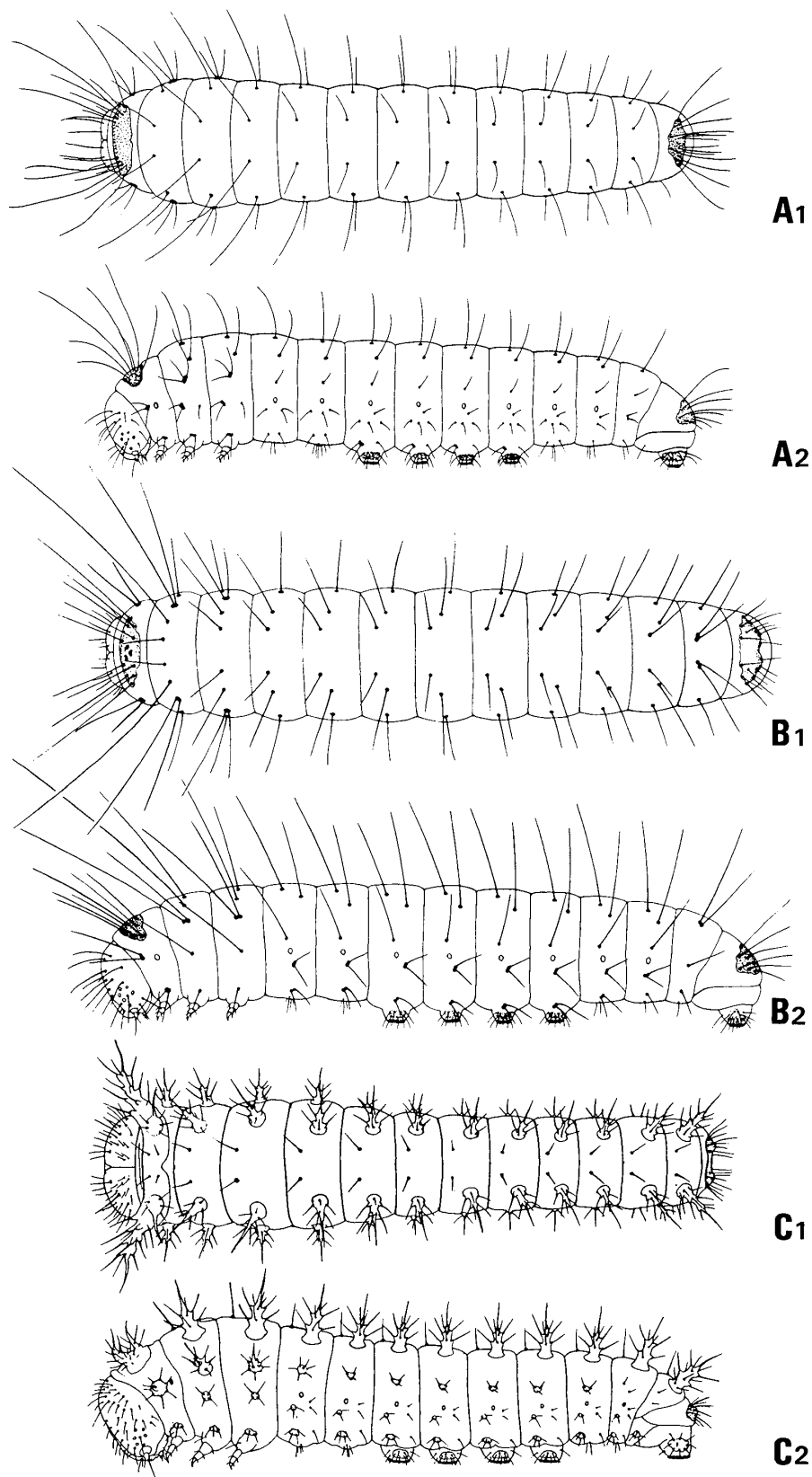



Fig. 7. First-instar larvae of three papilionid genera. A. *Teinopalpus imperialis*; B. *Luehdorfia japonica*; C. *Menelaides protenor*. 1. Dorsal aspect; 2. Lateral aspect.

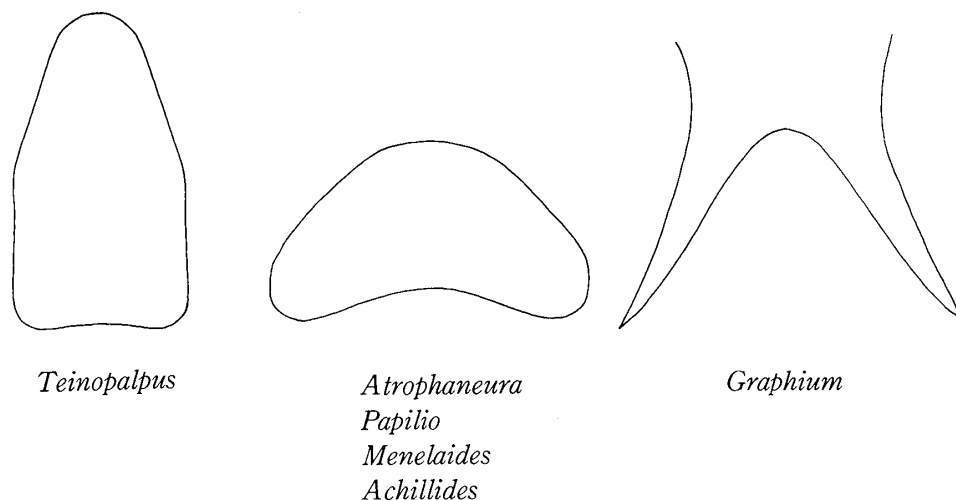



Fig. 8. Suranal plates in last-instar papilionid larvae (schematized).

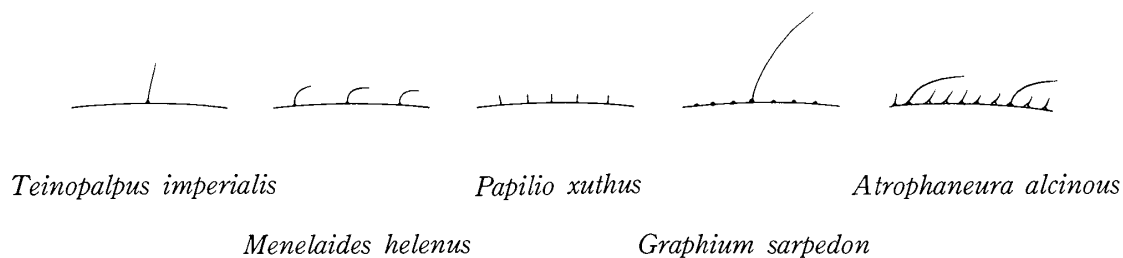



Fig. 9. Minute body hairs in last-instar papilionid larvae (schematized). A. *Teinopalpus imperialis*; B. *Menelaides helenus*; C. *Papilio xuthus*; D. *Graphium sarpedon*; E. *Atrophaneura alcinous*.

Graphium lacks dorsal markings on the abdomen, but green pupae of *Papilio, Menelaides* and *Achillides* have large yellow areas. The broad dorsal yellow zones on the abdomen in *T. imperialis* suggests its closer relation to *Papilio, Menelaides* and *Achillides*.

2. Adult morphology

Small compound eyes..specialization
Short antennae..specialization
Antennae without scale...............................similar to Papilionini
Short proboscis..............................similar to Leptocircini
Extremely long palpi..specialization
Prominent frontoclypeus.....................................specialization
Short legs.......................................similar to Leptocircini
Legs without scales...
............similar to Papilionini (leg scales exist in *Graphium* and *Parnassius*)

Forewing apex pointed, hindwing tails thin ....specialization
Sixth vein on female hindwing protruding to from a tail..........specialization
Median branch at base of forewing almost degenerate............specialization
Wing patterns of both sexes without parallel ....specialization
Wing forms extremely different between sexes ....specialization
Male hindwing flap on the inner margin narrow and devoid of androconic hair
....similar to Papilionini
Thorax and abdomen gross and thick ....specialization
Superuncus extremely well-developed and almost covering the uncus
....specialization
Trifid uncus (also in *Protographium* and *Eurytides*; uncus degenerate in most *Graphium* spp.) ....similar to Leptocircini
Morphology of valva.................................similar to Papilionini
Large, curved (like the letter C) phallus..........................specialization
Long, broad saccus ....specialization

3. Habits

The larval behaviour from hatching to pupation is mostly the same as in the Papilionini and Leptocircini. The male flight is rapid and skipping, somewhat suggestive of *Graphium* spp., but not sustained and soon comes to a halt. In contrast, the

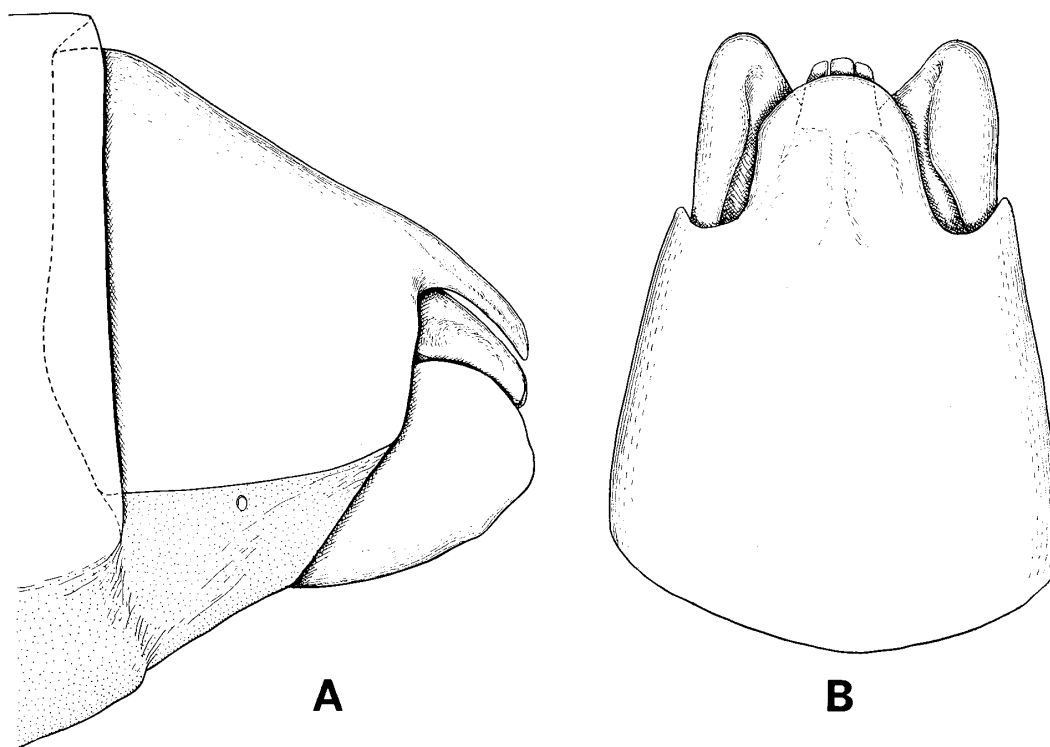



Fig. 10. Posterior portion (8th segment and genitalia) of male abdomen of *Teinopalpus imperialis himalaicus* ROTHSCHILD. A. Lateral aspect; B. Dorsal aspect.

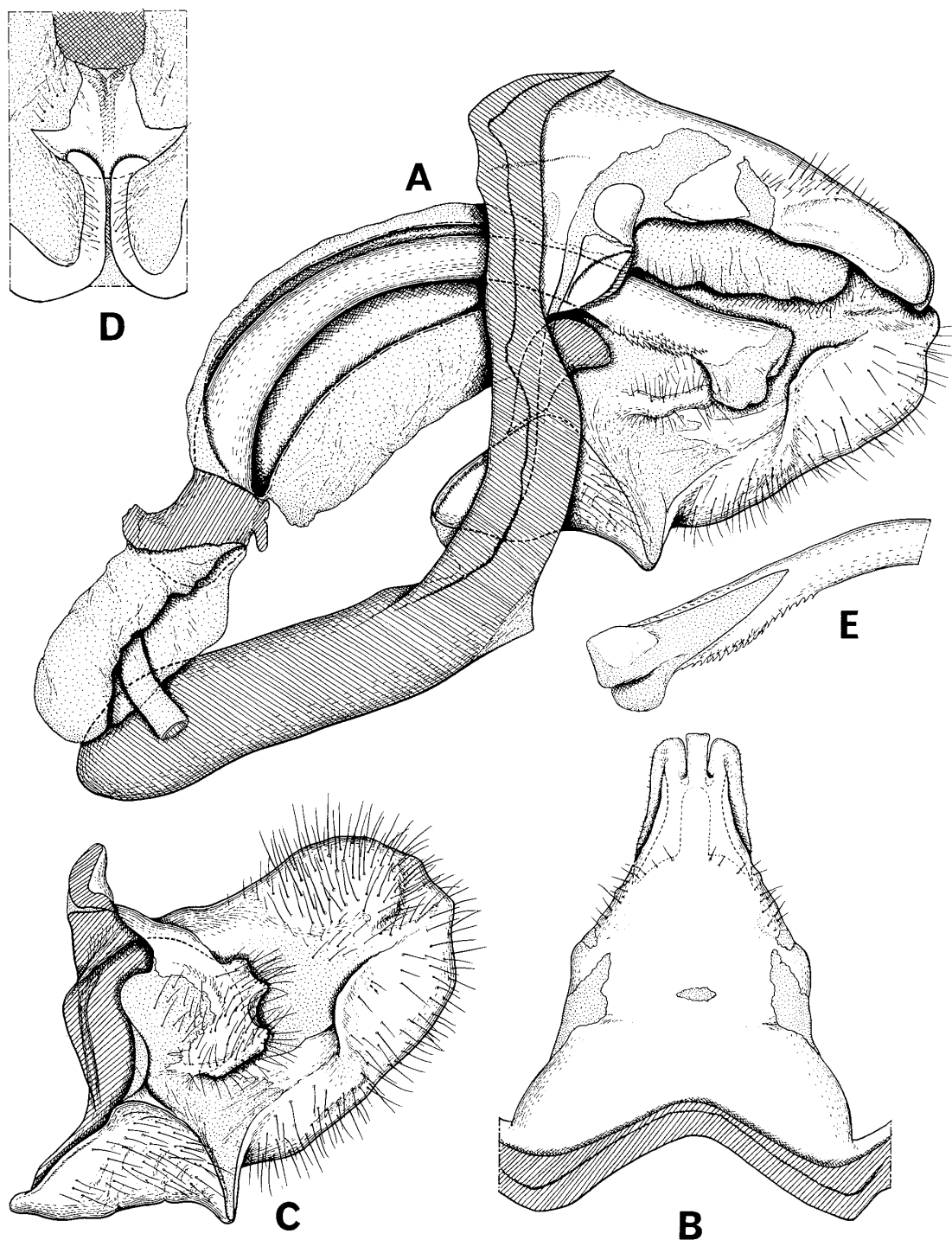



Fig. 11. Male genitalia of *Teinopalpus imperialis himalaicus* ROTHSCHILD. A. Lateral aspect, left valva removed except its dorsoproximal portion; B. Dorsum, dorsal aspect; C. Right valva, inner aspect; D. Juxta, posterior aspect; E. Apical portion of aedeagus, right lateral aspect.

female has a deliberate, slower and longer flight habit. No other papilionid shows such a remarkable sexual difference in flight, which is a distinctive character of this butterfly.

4. Larval food plants

Magnoliaceae, on which the larva of *T. imperalis* feeds, also host a number of species belonging to the Leptocircini, but almost none of the Papilionini.

Conclusion

The classification of this species has been reviewed on the basis of the author's findings, with emphasis on the morphological features of the younger stages.

This species undoubtedly evolved from the Zerynthiini, in view of the remarkable similarity in the chaetotaxy of the first-instar larva. The Papilionini evolved from the Zerynthiini, but *Teinopalpus* must have departed from the main stem of the Papilionini at a fairly early stage and taken the course of isolated specialization.

T. imperialis resembles *Achillides* in the later larval instars, despite the apparent fact that the former does not belong to the latter. The author believes that this discrepancy can be accounted for by parallelism in evolution. In his former work (1984) on the classification of Papilionidae, he proposed a new notion "stage of charac-

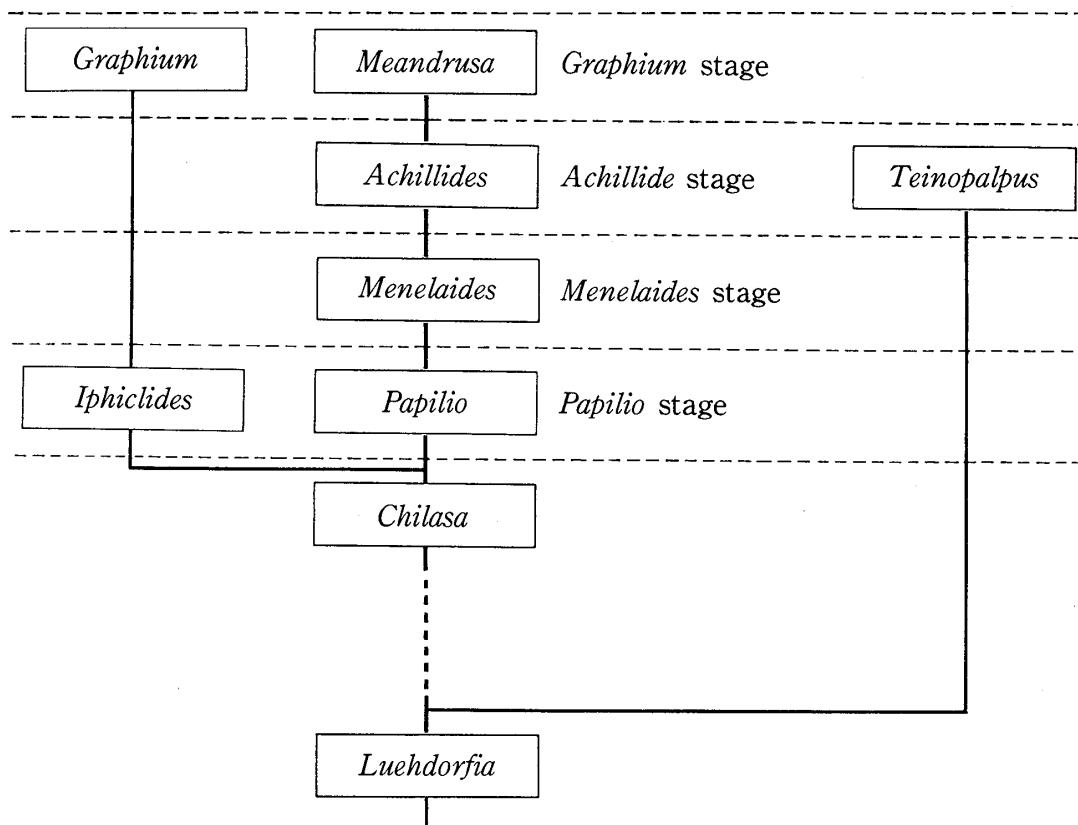



Fig. 12. Hypothetical position of *Teinopalpus imperialis* on a genealogical tree of the Papilionidae.

teristics." In other words, the different branches of a genealogical tree pass through various stages of evolution, and within the same stage, species and genera even belonging to different groups tend to have similar characteristics. He expounded this idea on the basis of adult features, but later found that it is also applicable to the characteristics of early stages. The position of *T. imperialis* among the Papilionidae can be explained in this context. It branched off the main stem at an early age and evolved independently farther away from the other papilionid groups, but came to possess characteristics similar to those of *Achillides* because, in the author's opinion, it had advanced to the stage of *Achillides* on its own.

The limited number of similarities between *T. imperialis* and the Leptocircini does not entitle it to belong to the Leptocircini. Therefore, the author concludes that *T. imperialis* falls under the category of the Papilionini.

References

BAILEY, F. M., *et al*. Note on *Teinopalpus imperialis*, *J. Bengal Nat. Hist. Soc.*, **14**: 123-126.

BRYK, F., 1934. Lepidoptera, Baroniidae, Teinopalpidae, Parnassiidae. Pars I. Tierreich, **64**: xxii+131pp.

EHRLICH, P. R., 1958. The comparative morphology, phylogeny and higher classification of the butterflies (Lepidoptera: Papilionoidea). *Kans. Univ. Sci. Bull.*, **39**: 305-370.

FORD, E. B., 1944. Studies on the chemistry of pigments in the Lepidoptera with reference to their bearing on systematics. 3. The red pigments of Papilionidae. *Proc. R. Soc. London* (A), 19. 4. The classification of the Papilionidae. *Trans. R. ent. Soc. London*, **94**: 201-223.

IGARASHI, S., 1984. The classification of the Papilionidae mainly based on the morphology of their immature stages. *Tyô to Ga*, **34**: 41-96.

MUNROE, E., 1960. The classification of the Papilionidae (Lepidoptera). *Canad. Ent. Suppl.*, **17**: 1-51.

SHIRÔZU, T., 1955. A study on foodplants of the Papilionidae in relation to evolution. (In Japanese.) *Shin Konchu*, 8 (4): 38-45, (5) 38-44, (7) 28-36.

STAUDINGER, O. & SCHATZ, E., 1885-92. Die Familien und Gattungen der Tagfalter (by SCHÄTZ, E., 1885-92; completed from 1888 by RÖBER, J.). *Ex. Schemett.*, **2** (6) +ii+292pp., 50pls

TALBOT, G., 1936. Fauna of British India, Butterflies 1 (Ed. 2): 1-300. London.

摘　　要

北インドにおけるテングアゲハの生活史とその分類学的位置
（五十嵐　邁）

序　　文

Teinopalpus imperialis テングアゲハは1843年HOPEによって記載されて以来，その幼生期についてかなり熱心な探索が行われたことがうかがわれる．F. M. BAILEY (1940) によって紹介されたものの一つは，H. J. ELWES (1888) の報告で，KNYVETTにより本種の蛹（複数）が *Daphne nepalensis* ネパールジンチョウゲの葉に付着したものが発見されたという話，他の一つはOscar LINDGRENにより1918年9月本種の終令幼虫が路上で拾われ，蛹化・羽化が観察されたという話である．いずれも産地名が明記されていないがDarjeeling周辺と考えられる．残念ながら両人とも幼虫，蛹の図もしくは写真を残していないので，

本種の分類学的位置は今日まで長く謎にとざされる結果となってしまった.

筆者がアゲハチョウ科の分類上, 本種の生活史解明がきわめて重要であることを認識し, 自身でその産地におもむいて調査を試みようと思いついたのは 1962 年のことであった. それが現実の形をとって現れたのが 1963 年の日本鱗翅学会ヒマラヤ蝶蛾調査隊によるネパールヒマラヤへの探検であった. 以後, 生活史解明に成功する 1986 年までの間に, 計 14 回の探索がネパールや北インドに対して行われた.

本種が個体数の少ないものであることに加え, 食餌植物が判明していなかったこと, 産地の天候がきわめて不順であることなどが調査を困難なものにし, 24 年間もの長年月にわたって生活史の解明を拒んできた.

幸い 1985 年, 1986 年の 2 回, 通算 5 ヶ月にわたる調査の結果生活史の一部が判明したので, 着色図をそえてここに発表する.

発表にあたり日頃ご指導を賜わる日本鱗翅学会会長白水隆博士, 日本鱗翅学会理事緒方正美博士, 日本鱗翅学会評議員黒沢良彦博士, 京都大学教授日高敏隆博士, 南山大学教授阿江茂博士, T. G. HOWARTH 氏, 九州大学教授三枝豊平氏, C. G. C. DICKSON 氏, 食餌植物の同定をお願いした元東京大学名誉教授故原寛博士, 東京大学黒沢幸子博士の諸氏に深甚な謝意を表する.

蝶の採卵に使用した採卵紙(濾紙に食草の抽出液を塗布したもの)に関しては京都大学農学部農薬研究施設教授の深海浩博士, 助手西田律夫の両氏ならびに藤永製薬研究所の鳥越泰義博士のご協力をいただいた. 厚く御礼申し上げる.

また探索の実施面においては原田基弘, 松香宏隆, 久保快哉, 工藤吉郎, 郡司芳明, 原啓一, 横倉明, 永見宏二, 柏原精一, 滝沢伸介, 増井暁夫の諸氏に一方ならぬお世話になった. 厚くお礼を申し上げる. D. M. WANKHAR 氏には Kashi Hill における本種の生態について種々の助言をいただいたことにたいして感謝を捧げる.

Darjeeling における長期滞在について種々便宜をはかって下さった Daku Tenzing NORGAY 夫人に深甚の謝意を表する. また Darjeeling の Tiger Hill における長期間にわたる研究生活中, 終始献身的な協力と奉仕を惜しまなかった Tiger Hill Tourist Lodge の Manager N. B. TAMANG 氏にたいして最大の謝辞を捧げる. 探索に同行した妻昌子の労をも多とする.

生　　活　　史

1. 習　　性

♂: 晴天の日の午前 7 時半から 12 時の間に限って活動する. 好んで山頂の樹木の頂部や岩に飛来して静止する. 他の♂が現れると猛烈な追飛を行なって駆逐する.

飛翔はきわめて敏速で, *Graphium* 属を思わせる跳躍型である. 静止する時は翅を全開または半開する. いったん静止すると長時間にわたって動かず, 時には手で触れても何の反応をも示さないことがある.

飛翔中に陽がかげるとただちに飛翔を中止し, 直降して近くの樹梢や地上に静止する. 曇った日でも, 何らかの刺激を受けると短時間飛翔することが稀に観察されるが, すぐに静止する.

筆者の野外における観察によれば, 摂食は通常, 葉上もしくは地上の水を吸うものに限られていたが, 滝沢伸介氏の Tiger Hill 周辺における 2 回の目撃によれば, ♂が低い草本の白い花を訪れ, 翅を開いて静止し吸蜜を行なったという.

♀: ♂と同様, 山頂部に飛来するものがもっともよく目撃される. どちらかといえば晴れた日を好むが, 無風快晴で雲のない日は飛ばない. 霧の切れ目に陽光が射す弱風の日をもっとも好む. また♂と異なって曇天もしくは小雨の中をも飛ぶ.

飛翔の時刻は午前 8 時半から 12 時半の間で, 今まで捕獲されたものは 11 時前後がもっとも多い.

過去に筆者および協力者が Tiger Hill 頂上において捕獲した♀は計 14 匹になるが, そのすべてが未交尾であった. そしてそれらはすべて新鮮で, 飛び古したものはなかった. この事実から, 頂上に飛来する♀は

交尾の機会を求めて舞い上がってくるのであって，風に吹き上げられて来るものではないと考えられる．（Tiger Hill頂上で得られる他の2種のアゲハチョウ *Achillides krishna* タカネクジャクアゲハ，*A. arcturus* オオクジャクアゲハの♀も未交尾のものがきわめて多いことは注目に値しよう．）

飛翔は♂ほど活発ではないが直線的であり，山頂に到達すると1，2回旋回して飛び去る．飛翔中，ネットが体をかすめると強い風によって目まいを起こしたかのように付近の物体にしがみつき，すぐには飛び去らないことが再度あった．

花，樹液，湿地などでの吸蜜，吸水の観察例は皆無であるが，筆者はビニール袋内の水滴を吸うのを観察している．薄めた蜂蜜を与えれば好んで摂取するほか，同じく薄めたウィスキーなども好んで飲む．しかしこれらのものを与えた場合，結果として寿命を縮めるもののようで，飼育の際には水のみを与えるのが無難と考えられる．

常時霧の立ちこめるもっとも多湿な地域に生息する昆虫でありながら，湿気に耐える力に乏しく，とくに密閉された多湿な状態におくと，短時日のうちに死亡する．

2．発生回数

Tiger Hill（標高2,585 m）における観察では，成虫は春季4月下旬より出現し，5月中・下旬に個体数がもっとも多い．6月もこれにつぐが，7月には激減し，8月には稀となる．しかし7－8月に得られる個体にも新鮮なものが多いところから考えて，羽化期は異常に長く5ヶ月間にまたがるものと考えられる．幼虫飼育の結果，もっとも順調に生育したものでも卵の産付から蛹化まで2ヶ月を要した事実から考えて，同地における発生は原則として年1回とみなしてよいと考えられる．ただし，室内飼育によるものは電灯による照射時間が影響を与えたのか，約半数が8－9月に羽化した．そして日本において冬季11匹の蛹を袋に入れて屋外に吊るしておいたところ，12月上旬にいたり4匹に羽化の徴候が認められた．そこで暖房のない室内（摂氏10－13°）に移したところ，12月下旬3♂1♀が羽化した．羽化した蛹はいずれも越冬蛹型（蛹の形態記載参照）であり，羽化した成虫は夏季に羽化した個体のように前翅先端が細長く左右に突出しない典型的な春型であった．Tiger Hillの冬季はきわめて寒さがきびしく，零下21°に達するといわれる．日本の本州の晩秋から初冬にかけての気温は摂氏7－13°程度であり，Tiger Hillの春季の気温とほぼ同じである．これが羽化の促進された理由と考えられる．

Mr. D. M. WANKHARによればKhasi Hill（標高約1,500 m）では9月にも多数の発生が見られ，同地では年2回の発生が充分考えられるという．Tiger Hillとの標高差が発生回数にも影響を与えているものと考えられる．

3．求愛行動

1985年7－8月の観察によれば，Tiger Hill頂上の北側約30 mの位置に生える高さ約15 mの樹木の頂部には常時1頭の♂が静止して飛来する♀を待っていた．

1985年8月25日午前10時05分，1♀が北西より頂上に飛来し1度旋回した後，ふたたび北方に進路をとってその木の頂と同じ高さを，約5 m離れて通過しようとした．♂はただちに飛び立ち♀に接近した．♀は速度をあげて逃避の姿勢を見せたが，♂は体が触れ合うまでに急迫して，2匹はほとんど一体となって急斜面の樹海を下方に向かって急降下した．♂も♀もふたたび姿を現さなかったので交尾は成立したものと考えられる．

4．交　尾

自然の状態における交尾を観察する機会には恵まれなかった．

1986年5月25日，野外で採集した良好な状態の1♂1♀を布製の吹流しに入れて自発的な交尾を期待したが，双方とも活発に行動して幾度も接触の機会があったにもかかわらず，ついに交尾は成立しなかった．

時刻は午前9時から10時の間，天候は晴，気温は摂氏18°であった.

Hand-pairingは同日同じ1♂1♀を用いて行なった. 交尾時間は午前10時19分ら12時35分まで2時間16分であった. 気温は摂氏20°であった.

1986年5月29日, 他の1♂1♀を用いてhand-pairingを試みた. 交尾時間は午前8時41分から9時48分まで1時間07分であった. 天候は晴, 気温は摂氏18°. 前回にくらべて低温度であるにもかかわらず所要時間は半分であった.

1986年6月6日，3匹目の♀が得られ, hand-pairingを試みたところ，この交尾は午後2時05分より5時45分まで3時間40分を要した. 天候は雨，気温は摂氏18°であった.

以上の3例でも判るとおり, 気温に大差がないにもかかわらず, 交尾時間に著しい差が生じるのは興味深い.（他に *Achillides krishna* タカネクジャクアゲハも夕刻の交尾に非常な長時間を要したことが観察されている.）

これらの交尾時間の差が産卵結果などに直接的な影響をおよぼした事実は認められない.

Hand-pairingに関する限り，交尾姿勢は他のPapilionidaeのものと変わりない.

5．人工採卵

1985年8月18日に採集した1♀を用いて，8月23日午後2時，つぎの諸種の植物を使って採卵を試みた. 当時は食餌植物が不明であったので，各科の植物を調査の対象とした.

Litsea Kingii	クスノキ科
Neolitsea zeylanica	クスノキ科
Xanthoxylum alatum	ミカン科
X. acanthopodium	ミカン科
Evodia flaxynifolia	ミカン科
Daphne nepalensis	ジンチョウゲ科

しかし，いずれの植物に対しても反応を示さなかった.

同年8月27日，午前8時30分から9時45分までの間に採卵紙による採卵を試みた.

Lindera unbellata クロモジ（クスノキ科） ……………………………………………反応なし

Liriodendron tulipifera ユリノキ（モクレン科） ……………………………………11個産卵

の結果を得た. これにより本種の食餌植物はモクレン科であると推定し，翌日はTiger Hill周辺に自生する *Magnolia campbellii* を与えたところこれに産卵した.

翌1986年6月5日，*M. campbellii* を用いて人工採卵を試み，12個の卵を得た. この結果から本種の食餌植物が *M. campbellii* であることはほぼ確実と信じるようになった. なぜなら，Tiger Hill頂上から約300 m下方までの間に本種以外のモクレン科植物は認められなかったからである.

このほか1986年, 日本から持参した次の3種の植物から作製した採卵紙を用いた結果, 次の結果を得た.

Illicium religiosum シキミ（モクレン科） ……………………………………………反応なし

Kadsura japonica サネカズラ（モクレン科） …………………………………………反応なし

Magnolia obovata ホオノキ（モクレン科） ……………………………………多数産卵した

このほか，Khasi HillにおいてD. M. WANKHAR氏により，何ら植物を入れないビニール袋内に♀を入れておいたところ，袋の内側に十数個の卵が産みつけられたが，孵化しなかったという報告を受けている.

人工産卵は1985年の観察では午前中に限って行なわれ, 午後に産んだのはわずか1個にすぎなかった. しかし1986年の実験では午後にも産卵することが判明した. いずれの場合も母蝶は直射日光を極度に嫌い, 産卵を拒んで激烈に暴れた. 淡い光線をもっとも好み, 夕刻に薄暗い室内で蠟燭3本の光のもとで産卵したこともある.

産卵姿勢は, 採卵紙もしくは与えられた葉の上に乗って翅を小刻みにはばたきながら1卵を産み, 数分間

飛びまわった後，同一ケージ内の離れた場所にある採卵紙または葉上にふたたび産む．突出した紙につかまってその裏面に産むことは決してなかった．この観察によって本種が野外において卵群を作らず1個ずつ産むこと，産卵位置が葉の表面であることが推定でき，それが正しかったことが後日判明した．

産卵数は1985年の観察では1日に10個前後に限られ，それ以上は努力にもかかわらず得られなかったが，1986年の観察では1日最大53個が得られる例が出現した．おそらくこれは個体差や前回までの産卵状況，母蝶の日齢などに起因する相違であろう．

6．産卵習性

自然の状態における産卵を目撃することはきわめて困難で，わずか1例が観察されたにすぎない．1986年7月2日午後2時55分，松香宏隆氏によってTiger Hill中腹（標高約2,535 m）において1♀が北方より飛来し，4本の *Magnolia campbellii* の樹上を旋回し，そのうちの1本の木の西側に向かって突出した枝の葉上に1秒あまり静止した後，ただちに飛び去ったのが目撃された．木の高さは約8 *m* で，♀の静止した枝はほとんど樹冠に近い位置であったため，双眼鏡による確認は不可能であった．翌日，その周辺の枝を切り落として調査したところ，成熟した大型の葉の表面の中脈上に産卵された1卵を発見した．葉の長さは約23 cmで，産付位置は葉柄の基部から9 cmの点であった．当日の天候は曇りで時折晴れ間があり，気温は約20°，やや高かった．

7．食　樹

Magnoliaceaeモクレン科植物の *Magnolia campbellii* HOOK. f. & THOMASを喰う．同種は北印では2,200 m以上の高地に限って自生する落葉喬木である．1986年7月，日本より持参した *Liriodendron tulipifera* L.ユリノキ（モクレン科），*Magnolia liliflora* DESR.モクレン（モクレン科），*M. obovata* THUNB.ホオノキ（モクレン科）を与えたところ，そのいずれをもきわめて好調に摂食した．

またDarjeeling地区の標高2,200 m以下の地域に自生する *Magnolia* sp.（常緑性）を与えたところ，これをもよく食べた．

これらの結果から，本種はモクレン科植物をかなり広く食樹としているものと推定される．すなわち，Tiger Hillよりも標高の低い *M. campbellii* の分布しない地域に産するものは，モクレン科の別の植物を喰っている可能性が充分にあると考えられる．

8．幼生期の生態

卵：卵期の長さは約15日であるが個体による変化が多く，産付された順に孵化するとは限らない．5月に産付された卵も，7月に産付されたものも，卵期の長さはほぼ同じであった．*Parnassius* をのぞく既知のアゲハチョウ科の各種に較べてかなり長い卵期といえよう．

卵の色は12日目頃まではほとんど変化せず赤紫色のままで，その後突然黒色の頭部が認められるようになる．黒色の頭部が確認され，卵の内部で幼虫が動くのが視認されてから孵化するまでは意外に長く，なお2日を要した．

1令幼虫：孵化後卵殻を底部を残して喰う．母蝶に卵を産付された固い葉を喰わずに移動して，紫色の若芽もしくは若葉だけを喰う．摂食時以外は葉の表面に絹の台座を築いてこれに静止する．

2令幼虫：葉の表面に静止する．静止時，体の中央付近から前半部を約45°折り曲げる習性がある．（Plate 4，右中）その際，通常右側に曲げるが，稀に左側に曲げるものも観察される．2令期は約6日間．

3令幼虫：2令期のように体を折り曲げる習性はなくなり，直線的な姿勢で葉の表面に静止する．静止中は胸部をふくらませ，腹部を縮める．3令期は約7日．

4令幼虫：葉の表面で葉柄の方に頭を向け，直射日光を避けて静止する．刺激を与えると肉角を出し，体を左右に振る．葉の表面に張りめぐらせる絹の台座は非常に強固で，幼虫を引きはがすことは容易でない．

幼虫は摂食時には，他の葉に移ってこれを喰い，終わるともとの台座に戻る．静止する時，胸部を大きくふくらませ，腹部を縮める．令期は個体による差が甚だしく，8日から2週間におよぶ．

終令幼虫：習性は4令期と大差なく，葉の表面に大量の糸を吐いて強固な台座を造って静止する．同地域の類似の環境に生息する *Achillides krishna* タカネクジャクアゲハ，*A. arcturus* オオクジャクアゲハ等にくらべて，台座に静止する幼虫を引きはがすことははるかにむつかしい．

摂食量も非常に大きく，長さ25 cm程度の大型の葉1枚相当の量を1日で喰う．

摂食の折唾液を分泌し，食痕の縁を約1 mmの幅で濡らす習性がある．糞は他のアゲハチョウ科にくらべて固く，とくに乾燥したものは著しく固い．糞の大きさは幼虫の体の大型なのに関連してきわめて大きく，直径約5.5 mm，長さ約6.0 mmで，*A. krishna* タカネクジャクアゲハの直径約4.0 mm，長さ約5.5 mmにくらべると容積が2倍にも達する．摂食は昼間よりも夕刻7時頃がもっともさかんである．5令期はきわめて長く，13日から19日にもおよぶ．ここでも個体による蛹化の時期の差が大きく拡げられる．

肉角はよほど苦しめないと突出せず，出しても全部を伸ばしきることはない．

蛹化時の胸部の帯糸は他のアゲハチョウにくらべてずっと長い．また前蛹期の姿勢も他のアゲハチョウにくらべて強く背を丸める．前蛹期は長く，4日を要する．

34例の蛹化は例外なく枝上に行なわれ，飼育袋内には多量の葉が存在したにもかかわらず，葉裏に付着した例は皆無であった．

形　　　態

卵：やや扁平な球形で，底部は浅い曲面をなして凹んでいる．色は赤紫色で，表面には半光沢がある．直径は約1.90 mm，高さは約1.52 mm．

1令幼虫：体の概形はtrue *Papilio* group（真正アゲハ群）に似て胸部がふくらんでいる．

頭部はわずかに黄褐色をおびる黒褐色で光沢があり，黒色毛を生じる．毛の配列はZerynthiiniタイスアゲハ族，Parnassiiniウスバシロチョウ族に見られる最原始型に似るが，若干本数が多い．Fig. 4のa，b，c 3本の刺毛が本種特有の刺毛である．頭幅は約1.07 mm．肉角は黄橙色である．前胸背板は茶色で，左右両端には1個の瘤状突起があり，各7本の長毛を生じる．毛は褐色で先端と基部は淡色，体の前方に向かって曲がる．体色は黒褐色で第3腹節基線に始まる白色の斜帯は第4腹節側面に拡がり，同節背面の後縁部において左右合一する．第5腹節は全域が白色を呈し，暗褐色の斑点が散在する．第6腹節において白帯は退化して気門線から基線の間にとどまる．第2胸節－第9腹節の背線の両側には各1本の暗褐色の長毛がある．また亜背線上にも各節1本の長毛を生じる．肛上板は茶色で16本の褐色の長毛をもつ．毛の先端は白い．胸脚は黒褐色で光沢がある．腹脚および尾脚は白色である．

2令幼虫：体の概形はTrue *Papilio* Groupに似て胸部がふくらむ．腹部後半部は他種にくらべて著しく細長いのが本種の特徴である．

頭部は緑褐色で光沢があり，頂部および側面には淡緑色の大斑紋を装う．頭幅は約1.69 mm．肉角は黄橙色．胴部の体色は体の前半部が褐色をおびた緑色で，後方に進むにしたがって褐色味を増し，ついには完全に褐色となる．前胸背板は同じく緑褐色で，左右両端には半球形の瘤状突起がある．第2，3胸節には背線両側および亜背線上に合計4個，第1－8腹節は各節の背線両側に各1個の水色円紋を装う．第4，5腹節の背面，側面には目の粗い白色の鞍形紋がある．また第3腹節から尾端にかけての基線上には顕著な白帯が縦走する．肛上板は褐色で光沢があり，褐色の短毛を生じる．胸脚は緑色，腹脚および尾脚は黄色味をおびた灰色である．

3令幼虫：体の概形は2令期と大差ないが，胸部3節は著しく扁平である．また腹部後半部は2令期のように細長くない．頭部は淡緑色で光沢があり，前面および側面には広く黄色の小点が散在する．そしてその中間には縦方向に帯状をなして黄色点の存在しない部分がある．頭幅は約2.52 mm．肉角は黄橙色であま

り長くない．胴部の体色はわずかに褐色をおびた緑色で，第1胸節から第1腹節前半部にかけて黒色の小点が散在するが，その範囲は気門線より上方に限定される．第1腹節後半部から尾端にかけては暗褐色の小点が散在する．前胸背板は体と同じ緑色で，小黒点が不規則に散る．前胸背板の左右両端には半球形の瘤状突起がある．第2，3胸節には背線の両側および亜背線上に，第1－8腹節には背線両側に各節1個の小円紋がある．紋の色は第2胸節－第3腹節間では水色，第4腹節以後は白色を呈する．第4，5腹節の背面，側面には目の粗い白色の鞍形紋を装う．第1腹節から尾端に達する基線上には顕著な白帯が縦走する．肛上板は2令期にくらべて頂部が上方に伸び，縦長になる．色は緑色で光沢がある．胸脚は淡緑色で，先端部はわずかに赤色味をおびる．腹脚および尾脚は黄橙色である．

4令幼虫：体形は3令期と変わらない．胸部3節は扁平で，背面は平らである．頭部は淡緑色で光沢があり，前面および側面には広く黄色の小点が散在する．そしてその中間には縦方向に帯状をなして黄色点の存在しない部分がある．頭幅は約3.67 mm．肉角は黄橙色で，中心線に向かって強く湾曲する．胴部の体色は深緑色で，第1胸節から第1腹節前半部にかけて黒色の細線状の切片模様が散在するが，その範囲は気門線より上方に限定される．第1腹節後半部から尾端にかけては不明瞭な暗褐色の円形小斑点が不規則に散在する．前胸背板は体と同じ深緑色で，大小の小黒点が不規則に分布する．

前胸背板の左右両端には半球形の瘤状突起がある．第3胸節亜背線上には1個の暗赤褐色の楕円形の眼状紋があり，その中心部には水色の小紋1個がある．第2胸節には背線両側および亜背線上に，第3胸節－第8腹節には背線両側に各節1個の小円紋がある．紋の色は第2胸節－第3腹節間は水色，第4腹節以後は白色である．第4，5腹節の背面，側面には白色の鞍形紋を装うが，これは3令期にくらべてやや白色部が広い．第1腹節から尾端にかけての基線上には顕著な白帯が縦走する．肛上板は縦長の梯形で，光沢のある緑色である．胸脚は淡緑色で光沢があり，先端部はわずかに赤色を呈する．胸脚および尾脚は濃黄橙色である．

5令幼虫：体の概形は true *Papilio* group に似て胸部がふくらむが，著しく扁平である．老熟するに従ってふくらみは顕著でなくなる．頭部はわずかに橙色をおびた淡緑色で光沢に乏しい．前額部も同じ色であるが光沢がある．頭部の色は下方に進むにしたがって黄橙色味が強くなる．頭幅は約5.59 mm．肉角は黄橙色で，4令期と同様内側に向かって湾曲する．肉角は体の大きさの割にはあまり大きくなく，その臭気は普通のアゲハチョウ科のものに似るが，より刺激的である．胴部の体色は濃緑色で，下方に下るに従って黄色味が強くなる．第1胸節から第1腹節前半部にかけて，黒色の細線状の切片模様が散在し，その範囲は気門線より上方に限られる．この切片模様は4令期にくらべて細長い．第1腹節後半部から尾端にかけては黒色で円形の小斑点が不規則に散在する．前胸背板は体と同じ濃緑色で，大小の小黒点が不規則に分布する．前胸背板の左右両端に存在する半球形の突起はきわめて小さく，ほとんど目立たない．第3胸節亜背線上の眼状紋は明赤褐色で周囲は細い黒色線に縁どられ，中心部に白色点がある．眼状紋に近接して背線側に太く黒色で縁どられた青色の小円紋がある．第1－8腹節には背線両側に各節1個の水色の小円紋がある．4令期まで存在した第4，5腹節背，側面にまたがる白色の鞍形紋は，5令の初期には残存するが老熟するにしたがって次第に消滅し，令末期には各節1個の白色の小斑点が残存するだけとなる．第1腹節から尾端にかけての基線上には顕著な鮮黄色の帯状紋が縦走する．肛上板は縦長の梯形で光沢のある緑色である．胸脚は紅色，腹脚および尾脚は鮮黄色を呈する．尾脚は角ばって体よりも外側に張出している．体長は静止時で63 mm と，非常に大きい．（*Achillides krishna* タカネクジャクアゲハは約48 mm）

前蛹期に入ると，頭部は灰褐色，体色は濃黄色に変わる．第1胸節－第1腹節間，第6腹節－尾端間の背面は強く紅色を呈する．また第2胸節背面には1個の緑色の楕円形斑紋がみとめられる．第1胸節から尾端にかけて気門上線上に1本種の赤褐色の太い帯状紋が縦走する．体の各節には多数の赤紫色の斑点が規則的に散在するが，第3胸節の眼状紋や，胸部，腹部各節の水色の円紋はまったく目立たなくなる．

蛹：体の概形は菱形で横幅が広く，著しく扁平である．頭部の先端は突出し，背面から見ると放物線をなすが，側面から見ると嘴形をなして尖る．頭部には他のアゲハチョウに見られる1対の頭頂突起もしくは突

起の痕跡はまったく存在しない．眼は小さい．口吻は短く前翅端に遠く達しない．触角は口吻よりわずかに短い．前脚の先端は触角の下にかくれる．中脚は先端のかなりの部分が触角の下にかくされるので，表面に現れる部分は前脚よりも短い．第2胸節背面には1本の長い緑色の突起がある．突起の背面側は左右の褐色の縁どり部分が隆起して中央の黄色部分よりも高くなっている．突起と体軸のなす角度は変化が多く，図示するものは直角に近いものである．第2－5腹節気門線部分は強く左右に張り出す．第5－7腹節の腹面には幼虫時の腹脚の痕跡が突起として顕著に残っている．体色は鮮緑色で半透明．どのような環境で蛹化させても褐色型は得られなかった．越冬蛹の体色はとくに背面において緑色味が強く，全体に透明度が高い．これにくらべて年内に羽化する個体は背面の黄色味が強く，不透明である．第2胸節背面の突起先端から発する1本の条模様は背線上を縦走して尾端に達する．1本のきわめて幅の広い黄色の帯が背線を中心として第3胸節から尾端に縦走する．この黄色帯は蛹化直後は顕著であるが，時間が経つにしたがって不明瞭となる．第3腹節－尾端間の気門線上には1本の太い暗緑色帯と，その腹面側に沿う1本の灰白色帯が縦走する．さらに，基線上にも1本の灰白色帯が縦走する．尾端の懸垂器は鮮やかな赤褐色を呈する．他のアゲハチョウでは背面からも懸垂器を見ることができるが，本種においては懸垂器が腹面側に存在するので背面からはまったく見ることができない．体を支える帯糸は長く，蛹体と付着物体とのなす角度は他のアゲハチョウに較べて著しく大きい．帯糸および尾端の台座の絹糸は黒褐色を呈する．平均体長は♂ 39.7 mm，♀ 40.1 mm，平均体幅は♂ 19.2 mm，♀ 20.2 mm．♀の平均体重は約4.2 gで，*Achillides krishna* の約2倍に達する．

所　　見

本種の分類学的位置についての問題点は，Papilionini アゲハチョウ族に属するか，Leptocircini に属するかの判定にある．この点に関する過去の研究者の説を見ると次のようになる．

FORD (1944)……Papilionini
白　水 (1955)……Papilionini
EHRLICH (1958)……Leptocircini
MUNROE (1960)……Leptocircini
五十嵐 (1984)……Leptocircini

今回，幼生期の形態が明らかにされたのでこれを加味して本種の分類学的位置について再考察を試みたい．

1．幼生期の形態

卵：側面から見た形はやや扁平で *Papilio*, *Menelaides*, *Achillides* に似る．*Graphium* は真円に近い．

1令幼虫：頭蓋の刺毛配列は，もっとも本数の少ない最原始型（*Luehdorfia*, *Parnalius*, *Hypermnestra*, *Archon*, *Meandrusa*, *Graphium* 等を含む）と，きわめて刺毛の本数の多い型（*Papilio*, *Menelaides*, *Achillides* 等を含む）とを比較の対象として選ぶと，明らかに最原始型に近い．すなわち，本種の刺毛配列は最原始型にわずか3本の刺毛を加えたにすぎないからである．

前胸背板については，*Papilio*, *Menelaides*, *Achillides* は背板の両端に発達した突起があり，これに常形毛を生じる．*Graphium* は前胸背板の両端に発達した突起があり，これにY字形毛を生じる．本種では前胸背板の両端の突起は発達せず瘤状をなすにとどまり，これに7本の長い常形毛を生じる．この形はかなり原始的なもので，*Luehdorfia* に似る．

胴部の各節の亜背線上には，*Papilio*, *Menelaides*, *Achillides* ではサボテン形突起があり，*Graphium* では数本のY字形毛を生じる瘤状突起があるが，本種では1本の長い常形毛を生じるのみで複雑な構造は見られない．これも *Luehdorfia*, *Parnalius* 等に似た形態である．ただし，気門線よりも下の部分には各節と

も刺毛の数は多く，*Chilasa*, *Papilio* に似る．

肛上板も *Luehdorfia*, *Parnalius*, *Menelaides*, *Papilio*, *Achillides* と同形であって，*Graphium* のように長い1対の突起をもつものとはまったく異なる．

体の概形は胸部がふくらみ，色彩斑紋については第4，5腹節に白色の鞍形紋を装うなど *Papilio*, *Menelaides*, *Achillides* に似た特徴をもち，*Luehdorfia*, *Parnalius* とはまったく異なり，同時に *Graphium* とも異なる．ただし，*Papilio*, *Menelaides*, *Achillides* らの白色鞍形紋は第3，4腹節上にあるのに対して，本種は第4，5腹節上にあることを見落としてはならない．

2－5令幼虫：細部において若干の差異はあるが，全体的には *Papilio*, *Menelaides*, *Achillides* に似ており，*Graphium* の特徴はみとめられない．とくに *Graphium* の胸部3節の亜背線上の突起や，尾端の肛上板上のよく発達した突起は痕跡すらみとめられない点において，*Graphium* との近縁性は感じられず，むしろ第3胸節の眼状紋，各節の水色円線，第4，5腹節の白色鞍形紋など，*Achillides* に類似した形質をもつことを思わせる材料が多い．肛上板は1令期と異なり縦長の梯形で，他属のものに似ない．胴部の表皮に生じる微毛はきわめて粗で，やや長い常形毛である．

蛹：頭頂部に1対となった突起をもたないこと，第2胸節背面に1本の顕著な突起をもつことなど，一見するときわめて *Graphium* に似た印象を与える．第2胸節の突起は，*Graphium* においては前蛹期に後方に倒れていたものであり，*Papilio* においては前方に倒れていたものである．本種においては前方に倒れていた点から発生的過程として *Graphium* よりも *Papilio* に近いものと考えられる．

腹部背線上には *Achillides* では顕著な1本の隆起線がみとめられるが *Graphium* ではそれを欠き，背線の両側を1対の隆起線が縦走する．本種では背線上に1本の線が縦走する点において *Achillides* に似る．

Graphium では腹部背面に斑紋を欠くが *Papilio*, *Menelaides*, *Achillides* においては黄色の大きな斑紋を装う．本種では背線をはさんで幅の広い黄色帯をもつ点において，*Papilio*, *Menelaides*, *Achillides* に近いことが感じられる．

2．成虫の形態

複眼は小さい……………………………………………………………………………………………特化
触角は短い………………………………………………………………Leptocircini 的，Papilionini 的
触角に鱗粉を欠く…………………………………………………………………………Papilionini 的
口吻は短い……………………………………………………………………………Leptocircini 的
下唇鬚が著しく長い…………………………………………………………………………………特化
前額は突出する……………………………………………………………………………………特化
脚は短い………………………………………………………………………………Leptocircini 的
脚には鱗粉を欠く ………………………………Papilionini 的（*Graphium*, *Parnassius* には存在する）
前翅端が尖り，尾状突起が細い……………………………………………………………………特化
♀後翅第6脈が突出し，尾状突起を形成する………………………………………………………特化
前翅基部の中脈分枝が著しく退化する……………………………………………………………特化
♂♀ともに斑紋が特異である…………………………………………………………………………特化
♂♀の翅形が著しく異なる……………………………………………………………………………特化
♂の後翅内縁の折り返しが浅く，発香毛を欠く…………………………………………Papilionini 的
胸部，腹部が著しく太い……………………………………………………………………………特化
♂交尾器の uncus 上方に super uncus が重なる…………………………………………………特化
♂交尾器の uncus の先端が三叉する（*Graphium* では uncus の退化したものが多い．先端が三叉するものには *Protographium*, *Eurytides* が知られる）……………………………………Leptocircini 的
♂交尾器の valva の形態 ……………………………………………………………………Papilionini 的

♂交尾器の phallus が大きく，C字型に曲がる ………………………………………………………………特化
♂交尾器の saccus は幅が広くて長い ……………………………………………………………………………特化

3．習　性

幼生期の習性は Papilionini, Leptocircini ともに大差がなく，本種もその範囲内に含まれる．成虫♂の飛翔はきわめて活発で跳躍的，やや *Graphium* を思わせるが，長時間飛翔することなくすぐに静止する．♀はやや遅鈍で直線的に長時間飛び続ける．♂♀でこのように飛翔習性の著しく異なるものはアゲハチョウ科の他属には見当たらず，Papilionini にも Leptocircini にも属さぬ特化した習性と言えよう．

4．食　性

本種の幼虫の食餌植物 Magnoliaceae モクレン科は Leptocircini の諸属には見られるが，Papilionini にはほとんど見出せない．

結　　論

著者は以上の諸形質，とくに形態的諸形質を重視して本種の分類学的位置を考えたい．

本種の1令幼虫の刺毛の数と配列がきわめて Zerynthiini に似ているという事実を考えると，本種がその進化の過程において Zerynthiini を通過したことは間違いなく，だからこそ Zerynthiini の形質がかなり明瞭に残されているものと考えられる．そして Zerynthiini の後，かなり古い時代において Papilionini の主幹から逸脱して特化の途をたどったものであろう．

本種が *Achillides* とは明らかに別の属でありながら2－5令幼虫がなぜこのように *Achillides* に酷似しているかについて，著者は次の解釈をしたい．

以前著者（1984）はアゲハチョウの系統進化に関して“素質の域”なる概念を提案した．すなわち，“進化の系統樹にはいくつもの枝が存在するが，その枝が通過する素質の域の中では異なった系統に属する種，属が互いに類似した形質を現す．”というものである．

著者(1984)はこの概念を主として成虫について議論したのであるが，その後研究を進めた結果，幼生期の形態についてもこの概念を適用できることに気づいた．

本種の場合もそのひとつで，系統的には Papilionini の主幹からはるかに遠ざかりながらも，進化の度合いが進むに従って *Achillides* の素質の域に到達したため，*Achillides* に似た形質が各所に出現したものと考えたい．

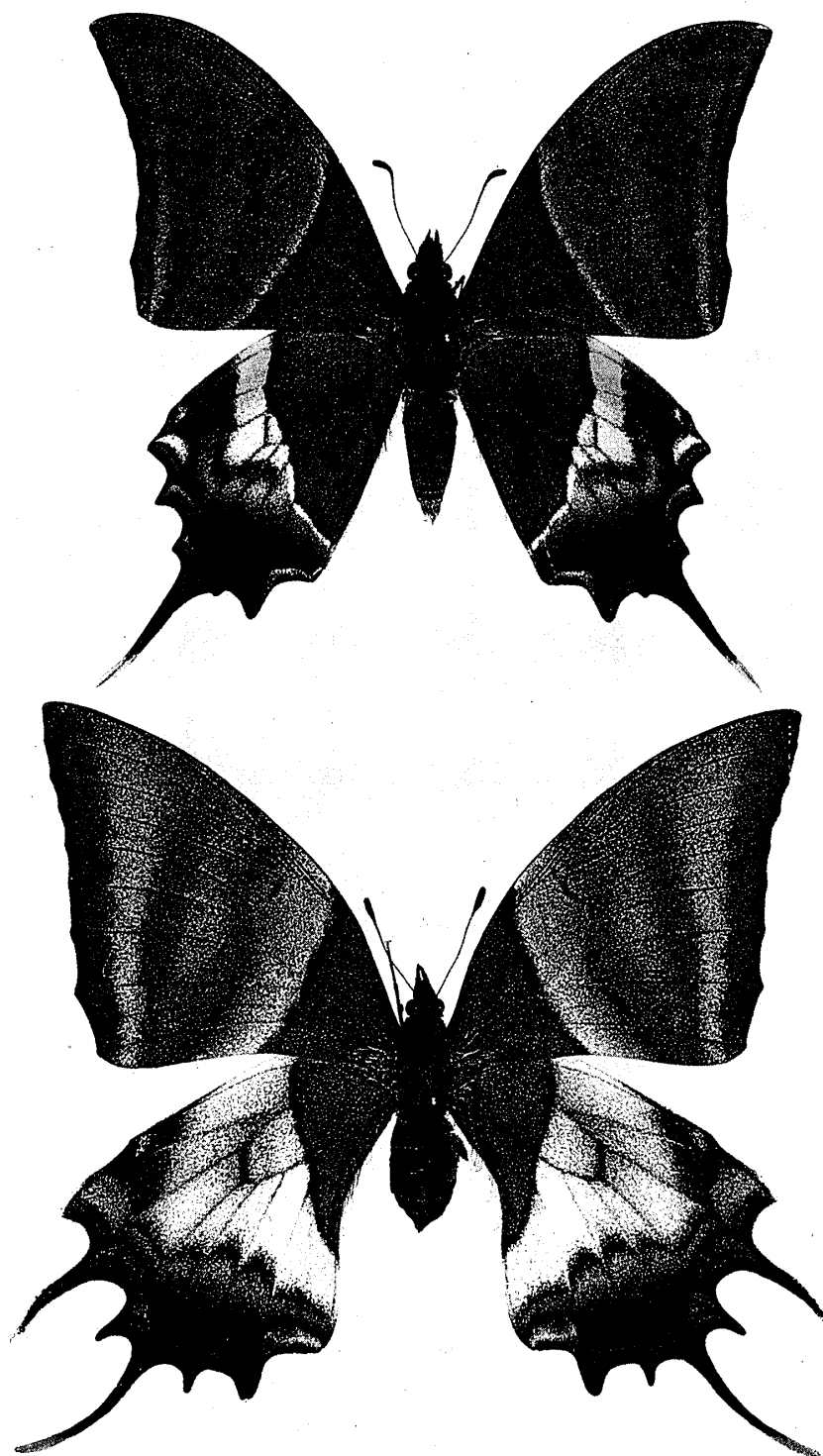
Leptocircini との関連については，本種の形態的諸形質の中には Leptocircini と同じものもしくは類似のものがほとんど存在しないところから，本種の位置は Leptocircini には属さず，Papilionini に属すると結論づけたい．

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Plate 2. Immature stages of *Teinopalpus imperialis*

0. Egg
1. First-instar larva
2. Second-instar larva
3. Third-instar larva
4. Fourth-instar larva
5. Fifth-instar larva

a. Dorsal and lateral aspects
b. Larval head skulls
c. Osmeteria
P. Dorsal and lateral aspects of pupa

1a
2a
3a
4a
5a
P
O
1b
2b
3b
4b
5b
1c
2c
3c
4c
5c
S. Igarashi
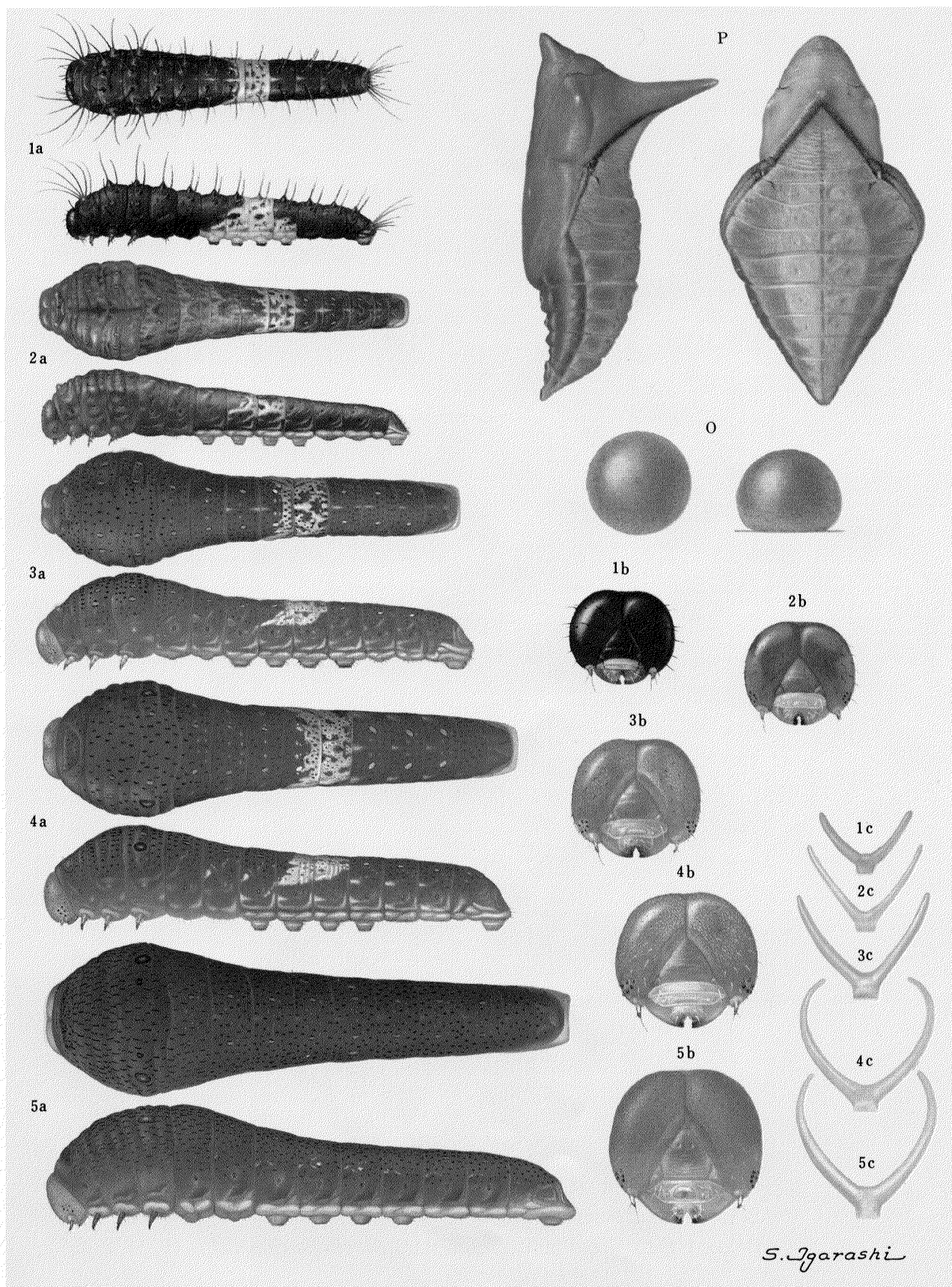
Plate 3.

Above : Summit of Tiger Hill (alt. 2,585 m), 20 June, 1986
Below left : Female in flight
Below right : Local larval food-plant *Magnolia campbellii* HOOK f. & THOMAS

〔Photo. MATSUKA〕

Plate 4.

Top left : Egg in situ on *Magnolia campbellii* (3 July, 1986)

Top right : Second-instar larva sitting with the fore part of the body bent

Middle left : Hand-paired butterfiles (6 June, 1986)

Bottom left : Fourth-instar larva at rest, with the thorax flattened

〔Photo. MATSUKA〕

Bottom right : Emergence of a female (23 August, 1986)

〔Photo. IGARASHI〕